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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 : F16C 33/20

A1

(11) International Publication Number: WO 93/22576

(43) International Publication Date: 11 November 1993 (11.11.93)

(21) International Application Number: PCT/GB93/00819

(22) International Filing Date: 20 April 1993 (20.04.93)

(30) Priority data: 9208782.4 23 April 1992 (23.04.92) GB

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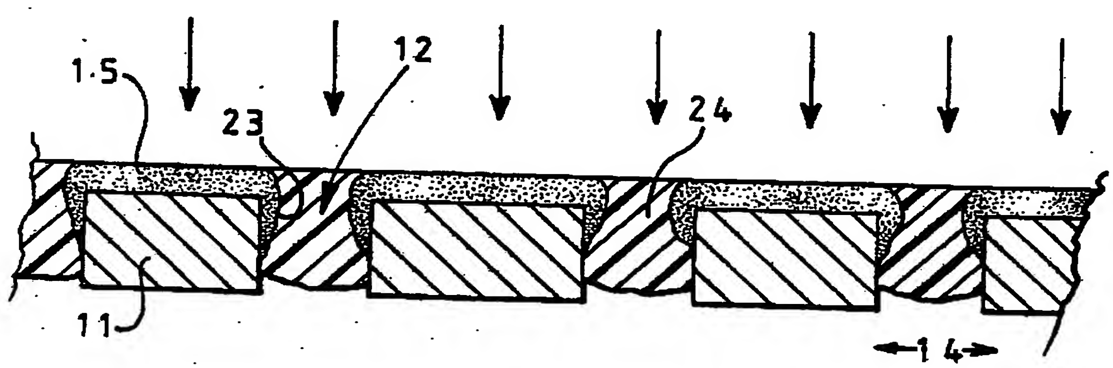
(81) Designated States: GB, JP, US, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published

With international search report.

(54) Title: LOW FRICTION LOAD BEARING MATERIAL



(57) Abstract

A load friction load bearing material (10) comprises a substrate (11) in the form of a sheet of steel having perforations (12). The surface (13) is discontinuous to receive a flame sprayed coating (15) of molybdenum with relief of thermal stresses. A surface coating of ptfe (24) is then applied in powder form and is sintered under pressure so as to be mechanically bonded to the openings (12) and the porous molybdenum coating (15). The resulting low friction load bearing material can be used in such applications as machine tool slideways.

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LOW FRICTION LOAD BEARING MATERIAL

This invention relates to a low friction load bearing material.

The invention was particularly devised to provide a friction reducing material for slideways such as those of machine tools. However it may be more broadly applicable.

Slideways of machine tools need to be accurately flat, and to remain dimensionally stable. However, they may carry heavy loading in use. They are also used under conditions where they may be subject to dirt, metal swarf, oil and other contaminants.

These factors combine to make it difficult to provide satisfactory friction reduction on machine tool slideways.

In one prior proposal, the slideway is made of cast iron, which can be lubricated with oil if desired. This provides the necessary strength characteristics, but inferior friction reducing properties.

It has been attempted to reduce friction using the properties of polytetrafluoroethylene (ptfe), but this material is difficult to apply satisfactorily to the slideway. In one method, a ptfe material is provided. At the surface of the material, acid etching is used so as to provide surface texture to the ptfe. An adhesive is used to secure the etched surface to the slideway, the adhesive being mechanically bonded to the surface texture of the material.

This method provides a very low friction surface, but the adhesive connection is weak and there is a tendency for the material to peel away from the slideway under conditions of use. This is aggravated by the tendency for ptfe to stretch and distort under moving loads and by the abrasive effect of

any metal swarf present.

Ptfe is chemically inert and is therefore very difficult to adhere to a substrate. On sintering it expands by about 25%, approximately ten times the rate of expansion of steel for example, whereas on cooling it shrinks by some 30%. It will be seen that differential expansion alone is likely to cause it to separate from a substrate.

For practical reasons it has therefore been used in powder form in a carrier medium such as a lead sludge or in a settable epoxy resin. Where it is desired to have pure ptfe or only selected additives, the material poses severe practical problems.

Viewed from one aspect, the invention provides a low friction load bearing material and viewed from a further aspect it provides a method of making such a material.

According to the invention there is provided a low friction load bearing material comprising a metal substrate having a surface and a layer of solid low friction material adhering directly to the surface characterised in that the surface is discontinuous and the low friction material is particulate and is sintered directly onto the surface under conditions of heat and pressure.

The low friction material may comprise ptfe and in a particular form may consist solely of pure ptfe.

The discontinuous surface may be perforated.

In a preferred embodiment, the surface is flame sprayed with a hard metal. The hard metal may be molybdenum or steel for example.

The invention further provides a method of making a low friction load bearing material comprising taking a substrate having a surface and adhering a layer of solid low friction material directly to the surface characterised by the steps of providing discontinuities in or on the surface, applying the low friction material in particulate form, applying pressure to the particulate low friction material and heating to sinter the low friction material directly to the surface.

The material may be cooled while retaining the pressure.

The method may include an additional step of flame spraying the surface with a hard metal before sintering the low friction material thereon.

The invention will now be described in more detail by way of example only with reference to the accompanying drawings in which

Figure 1 diagrammatically illustrates a friction reducing means intended for use on a machine tool slideway, with parts of the surface broken away,

Figure 2 is a sectional view through the friction reducing means of Figure 1 to illustrate its method of manufacture,

Figure 3 diagrammatically illustrates a flame spraying apparatus.

Referring to Figures 1 and 2 of the drawings, a friction reducing means is generally indicated at 10 and comprises a base or substrate 11 which is made of metal sheet or plate. The particular metal and its dimensions are selected for the intended purpose.

A plurality of openings 12 are provided in the substrate 11 so that its upper surface 13 is discontinuous. The pattern of

openings 12 may be regular or random but the desired effect is to break up the surface 12 in such a way that the maximum spacing 14 between the openings is below a distance selected by criteria relating to the materials used, which will be discussed below.

The openings 12 are, in the illustrated embodiment, through openings. However they could merely be surface depressions or other formations for rendering the surface 13 discontinuous.

Further discontinuity is created by flame spraying the surface 13 with a thin layer 15 of a hard metal. The preferred metal is molybdenum which is extremely hard and durable, has low intrinsic friction and tends to work harden with applied forces.

The flame spraying is carried out by an apparatus similar to that diagrammatically illustrated in Figure 3 in which acetylene is applied to a central pipe 16 into an oxygen atmosphere provided within a concentric pipe 17, the metal being fed into the resulting flame 18 in rod or wire form at 19. Compressed air in a surrounding sheath 20 forces the vaporised particles of molybdenum in a stream at 21 onto the substrate 22, the whole apparatus being moved as illustrated in the arrows to lay down a thin coating of molybdenum.

It is known to provide a molybdenum coating on for example steel for producing a wear resistant and relatively low friction surface. However the process carried out at present has limitations since the individual layers of molybdenum are only about fifty microns in thickness. As succeeding layers are added by flame spraying, the cooling of the layers underneath causes stress to build up between the substrate and the coating. The thicker the coating which is built up, the greater the stress within it and the greater the tendency for the coating to strip up off the substrate. It is possible to heat the substrate but this only has a marginal effect on the

possible thickness of coating. The maximum tends to be about 750-800 microns.

If the substrate is thin, the stresses in the molybdenum coating tend to cause it to bend or curl; if the substrate is thick, the coating may peel off.

By providing a plurality of openings 12, the maximum length of surface available to the molybdenum spray coating is the relatively short length 14 which limits the amount of stress which can build up due to difference of temperature and expansion coefficient between the molybdenum and the steel. This assists the molybdenum coating to stay firmly adhered to the steel substrate.

The effect is reinforced by the over spraying of the metal which tends to lodge in the tops of the openings 12 as seen in the sectional view of Figure 2, indicated at 23.

The molybdenum coating 15 therefore provides a porous surface layer on the substrate 11 and, in addition, somewhat penetrates into the openings 12 tending to close the mouths of the openings a little.

Although optional, the flame spraying with molybdenum assists in making a very secure bond between the metal substrate (typically steel), and a layer 24 of low friction material. The low friction material may be ptfe although other forms of low friction material may be used.

Ptfe is difficult to bond to a surface because it is chemically very inert. It also expands very substantially on sintering, to the extent of perhaps 25% and then contracts by about 30% on cooling. It is therefore very difficult to make a mechanical bond and impossible to make a chemical bond to hold it onto a substrate.

In order to attempt to overcome these difficulties, it has previously been proposed to use a carrier in admixture with the ptfe in a powder form. For example ptfe powder and a lead based material have been formed into a sludge or paste and applied to a substrate. Alternatively, the ptfe has been used in powder form as a filler in a settable epoxy resin.

To obtain the best low friction effect, it is preferable to use pure ptfe. For other reasons, for example dissipation of heat, it may be desirable to use an additive such as bronze powder. However the additive if any should be chosen for the intended use and not primarily in order to make the ptfe adhere to the substrate.

Since the ptfe expands approximately ten times as much as the steel substrate, it has hitherto not proved successful to sinter the ptfe powder directly to the substrate. However in the process of the present invention, the ptfe is applied in powder form to the substrate and a pressure cycle is applied during the heating process by which the ptfe powder is sintered to the metal.

The ptfe layer 24 is applied in powder form or an aqueous dispersion of ptfe may be used to increase penetration of the porous surface. A substantial pressure is firstly applied as illustrated by the arrows in Figure 2. It is preferred to use a maximum pressure of approximately 6400 tonnes per square metre to consolidate the ptfe. The material is heated to a temperature of 360 degrees Celsius under pressure, and the pressure may then be reduced during sintering, for example to about a quarter to one fifth of the maximum. This reduced pressure is retained until the sintering is almost complete. The pressure is then increased towards the maximum and the material is allowed to cool under high pressure. Thus, the normal expansion of the ptfe during the heating process is contained by the cycle of pressures applied. When sintering is complete and the heating is discontinued, the normal

shrinkage of the ptfe is again resisted because of the high pressure applied which is retained until the material reaches more or less ambient temperature. It may be possible to apply a constant pressure throughout but high pressure tends to increase sintering times.

The porous spray coating of molybdenum 15 assists in providing a mechanical key to which the ptfe powder can be sintered. Furthermore, the over spray 23 reduces the width of the mouth of each of the openings 12 and hence the ptfe tends to bulge in a general mushroom formation within the openings 12, giving strong mechanical keying.

When complete, the low friction load bearing material 10 can be secured to a machine tool slideway for example by simply screwing it on. It can be cut to size if required.

In addition to the basic process outlined above, the metal substrate could be provided with grooves or could be shotblasted or etched before the process takes place. In the event that it is not required to provide a molybdenum coating, for example for a relatively low load bearing material, the shot blasting or etching may provide sufficient mechanical keying, provided that the ptfe is sintered on under pressure.

Again, although the discontinuities in the surface have been described as being through holes, in some circumstances it may be preferred simply to use depressions, dimples, grooves, undercut channels or other formations provided that these break up the surface area to a sufficient extent. It has been found that the effective length between discontinuities should be between 5mm and 50mm where the substrate is steel and it is being flame sprayed with molybdenum.

As an alternative, it may be possible to use other materials such as stainless steel in spray form, or a combination of materials.

The invention provides a material which can be readily handled and fixed to its point of use, which can have very high load bearing qualities and in which the use of a metal substrate prevents or greatly reduces the tendency of the ptfe low friction surface to creep or lift. The intimate mechanical bond between the ptfe and the substrate reduces distortion, resists the stripping off of the ptfe and hence produces a very durable product. The additional use of molybdenum, although optional, may produce higher load bearing and even more durable mechanical bonding. If desired, the molybdenum can be sprayed on in a localised layer, for example at the leading edge of a moving part, for localised added strength.

CLAIMS

1. A low friction load bearing material comprising a metal substrate having a surface and a layer of solid low friction material adhering directly to the surface, characterised in that the surface is discontinuous and the low friction material is particulate and is sintered directly onto the surface under conditions of heat and pressure.

2. A material according to claim 1 further characterised in that the low friction material comprises ptfe.

3. A material according to claim 2 further characterised in that the low friction material consists solely of pure ptfe.

4. A material according to any preceding claim further characterised in that the discontinuous surface is perforated.

5. A material according to any preceding claim further characterised in that the surface is flame sprayed with a hard metal.

6. A material according to claim 5 further characterised in that the hard metal is molybdenum.

7. A material according to claim 5 or claim 6 further characterised in that the hard metal is stainless steel.

8. A method of making a low friction load bearing material comprising taking a substrate having a surface and adhering a layer of solid low friction material to the surface, characterised by the steps of providing discontinuities in or on the surface, applying a low friction material in particulate form, applying pressure to the particulate low friction material and heating to sinter the low friction material directly to the surface.

9. A method according to claim 8 further characterised in the step of cooling the material while retaining the pressure.

10. A method according to claim 8 or claim 9 further characterised in the step of flame spraying the surface with a hard metal before sintering the low friction material thereon.

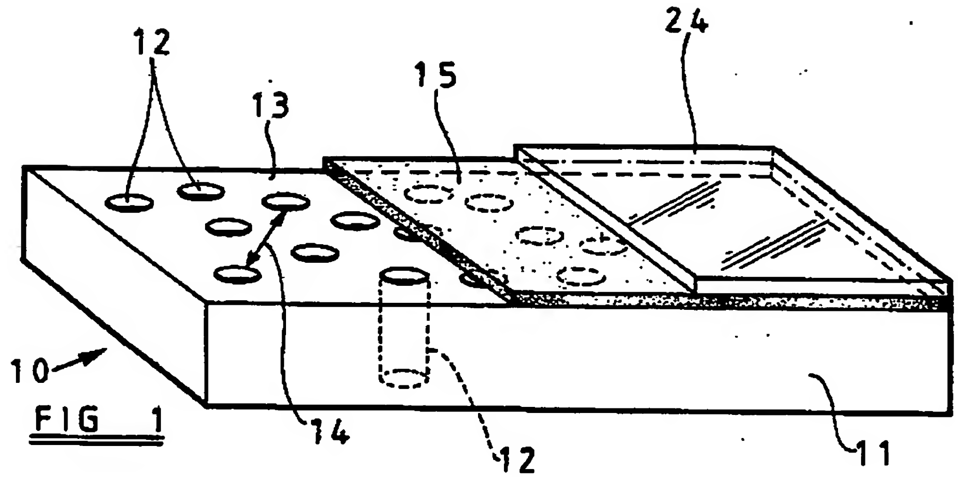

FIG 1

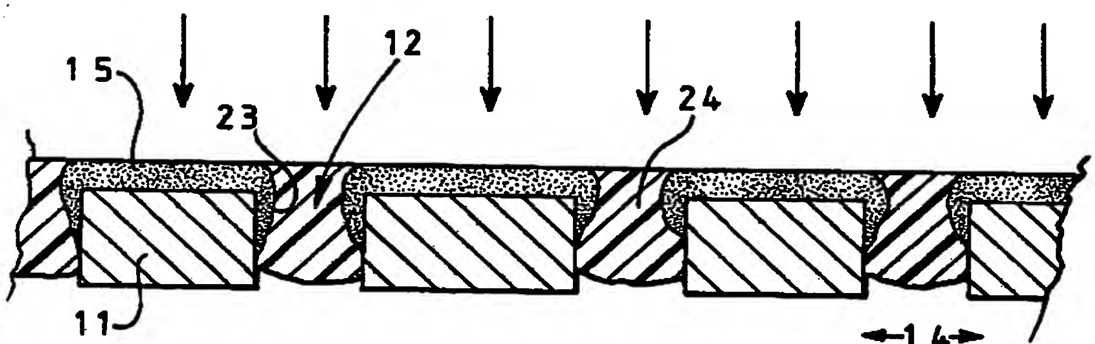

FIG 2

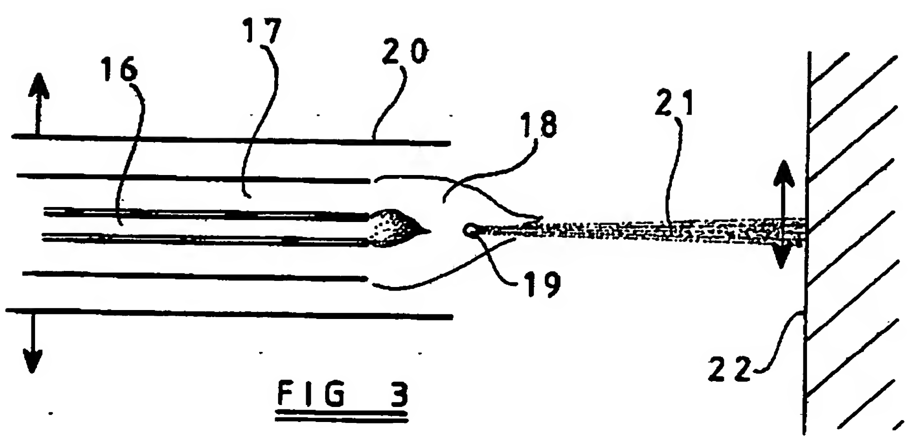

FIG 3

INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 93/00819

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 5 F16C33/20

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
Int.Cl. 5	F16C

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category°	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No.[13]
X	US,A,2 976 093 (REILING) 21 March 1961 see column 1, line 17 - line 26 see column 5, line 21 - line 57 see column 5, line 73 - column 6, line 3 see claims 9-11 see figures 6-9	1-4,8
X	US,A,4 238 039 (COOPER ET AL.) 9 December 1980	1,4
A	see figures 4,5 see column 3, line 12 - line 60	8
X	US,A,3 395 437 (GRAD) 6 August 1968	8
A	see column 3, line 32 - line 55 see column 3, line 64 - line 71 see column 4, line 5 - line 23 see figures 5-7	1-4,9

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° Special categories of cited documents : [10]

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
21 JULY 1993	30. 07. 93
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	GUTHMULLER J.A.

Form PCT/ISA/210 (second sheet) (January 1985)

International Application No PCT/GB 93/00819

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category°	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
A	US,A,2 276 143 (BELL) 10 March 1942 see figures see page 2, right column, line 39 - line 45 see page 3, left column, line 19 - right column, line 7	1,4,8
A	EP,A,0 060 725 (AE PLC) 22 September 1982 see page 4, line 18 - line 29 see figures 1-8	5,10
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ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. GB 9300819 SA 72705

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the European Patent Office EDP file on 21/07/93
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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82